LIBBY ASBESTOS SITE
OPERABLE UNIT 3
AUGUST 21, 2007

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TITLE:
NOTES FROM AUG 21, 2007
MEETING IN LIBRY

Libby Asbestos Superfund Site
Operable Unit 3

Remedial Investigation Scoping Meeting
August 21, 2007
Venture Inn
443 Highway 2 West
Libby, Montana

AGENDA

9:00 – 9:20 am	**Introductions**
9:20 – 9:45 am	**Overview of the Superfund Remedial Investigation Process and Current Schedule for OU3**
9:45 – 10:45 am	**Description of Operable Unit 3 (what we know and don't know)** • Physical Setting • Mine History and Operations • Current Land Ownership and Land Uses • Summary of Existing Site Characterization Data
10:45 – 10:55 am	**Break**
10:55 – noon	**Development of Preliminary Conceptual Site Models (what we're going to investigate)** • Human exposure – Asbestos • Human exposure – Non-asbestos • Ecological exposure – Asbestos • Ecological exposure – Non-asbestos
Noon – 1:00 pm	**Break for Lunch**
1:00 – 1:30 pm	**Introduction to Asbestos Analytical Capabilities for Various Environmental Media**

1:30 – 3:45 pm	**Discussion of Phase I Remedial Investigation Sampling Strategy**

Sampling to Investigate Nature and Extent of Contamination

- Objectives
- Soil and mine waste within disturbed areas at the mine
- Groundwater, seeps, springs
- Ambient Air
- Rainy Creek Road
- Surface Water and Sediment
- Tree Bark and Soil

Sampling to Support Assessment of Ecological Risks

- Objectives
- Surface Water and Sediment
- Aquatic and Terrestrial Biota

3:45 – 4:00 pm	**Break**
4:00 – 4:30 pm	**More Discussion and Summary of Feedback to EPA on Sampling Strategy**
4:30 - 5:00 pm	**What to Expect From Here – Schedule for Review of Draft Plan**

OVERVIEW OF PHASE I SAMPLING
Operable Unit 3 - Libby Mine Site

Medium	General Location	Sampling Locations	Notes	Sample Analyses									
				LA	Metals	Other Inorganic + Major Ions (e)	VPH/EPH	PCB	Pest/Herb	SVOC	VOC	Rad	Cyanide
Mine waste	Mine area	13 composites from mine waste areas	metals - dried, sieved (2 mm) LA - PLM-VE	X	X		X	X (a)	X (a)	X (a)	X (a)	X (a)	X (a)
Roadway materials	Rainy Creek Road	3 composites from unpaved roadway	metals - dried, sieved (2 mm) LA - PLM-VE	X	X		X	X					
Surface water & Sediment	Rainy Creek	1 upstream, 5 downstream	metals - total & dissolved fractions LA - TEM EPA 100.2	X	X	X	X	X (b,c)	X (b,c)	X (b,c)	X (b,c)	X (b,c)	X (b,c)
	Site Ponds	1 tailings pond, 1 holidng pond (+ others identified during field survey)	metals - total & dissolved fractions LA - TEM EPA 100.2	X	X	X	X	X (b,c)	X (b,c)	X (b,c)	X (b,c)	X (b,c)	X (b,c)
	Flintwood Creek	2 stations	metals - total & dissolved fractions LA - TEM EPA 100.2	X	X	X	X						
	Carney Creek	2 stations	metals - total & dissolved fractions LA - TEM EPA 100.2	X	X	X	X						
On-site seeps/springs	Mine area	2 seeps, 1 spring on Carney Creek (+ others identified during field survey)	metals - total & dissolved fractions LA - TEM EPA 100.2	X	X	X	X						
On-site groundwater	Mine area	<6 (?) possible wells	metals - total fraction LA - TEM EPA 100.2	X	X	X	X					X (d)	
Ambient air	Around mine	2 rings, 4 stations each	Low-flow, long duration	X									
Tree bark	Forest around mine	7 transects, 8-10 samples each	TEM after ashing	X									
Forest soil	Forest around mine	7 transects, 8-10 samples each	PLM-VE	X									

LA = Libby amphibole
VPH/EPH = volatile and extractable petroleum hydrocarbons
PCB = ploychlorinated biphenyls
SVOC = semi-volatile organic compounds
VOC = volatile organic compounds
Rad = gross alpha and beta

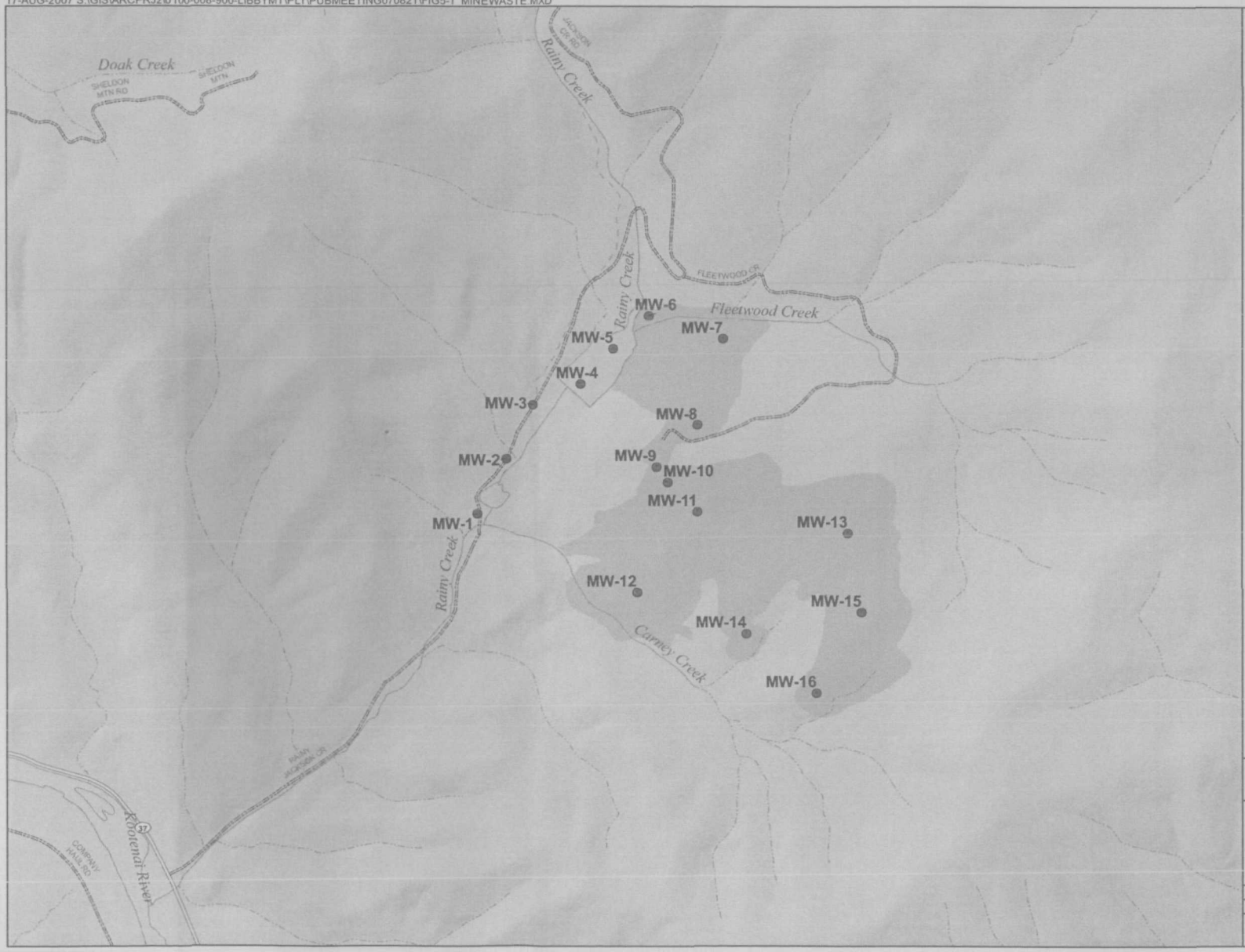
(a) Analyses to be performed for tailings from impoundment (MW-4 and MW-5).
(b) Analyses to be performed for surface water from tailings impoundment (TP), tailings impoundment toe drain (TP-Toe), and lower Rainy Creek below Carney Creek (LRC-1)
(c) Analyses to be performed for sediment from below tailings impoundment (TP-Toe) and lower Rainy Creek (LR-1).
(d) Analysis will include radium and uranium.
(e) Surface water and groundwater samples only.

Color Map(s)

The following pages contain color that does not appear in the scanned images.

To view the actual images, contact the Region VIII Records Center at (303) 312-6473.

17-AUG-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PUBMEETING070821\FIG5-1 MINEWASTE.MXD



Legend

- Open Water
- Perennial Stream
- Intermittent Stream
- County Road
- Primary Road
- Mine Disturbance
- Mine Waste Sample Location

DRAFT

N

0 2,000 4,000

Feet

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

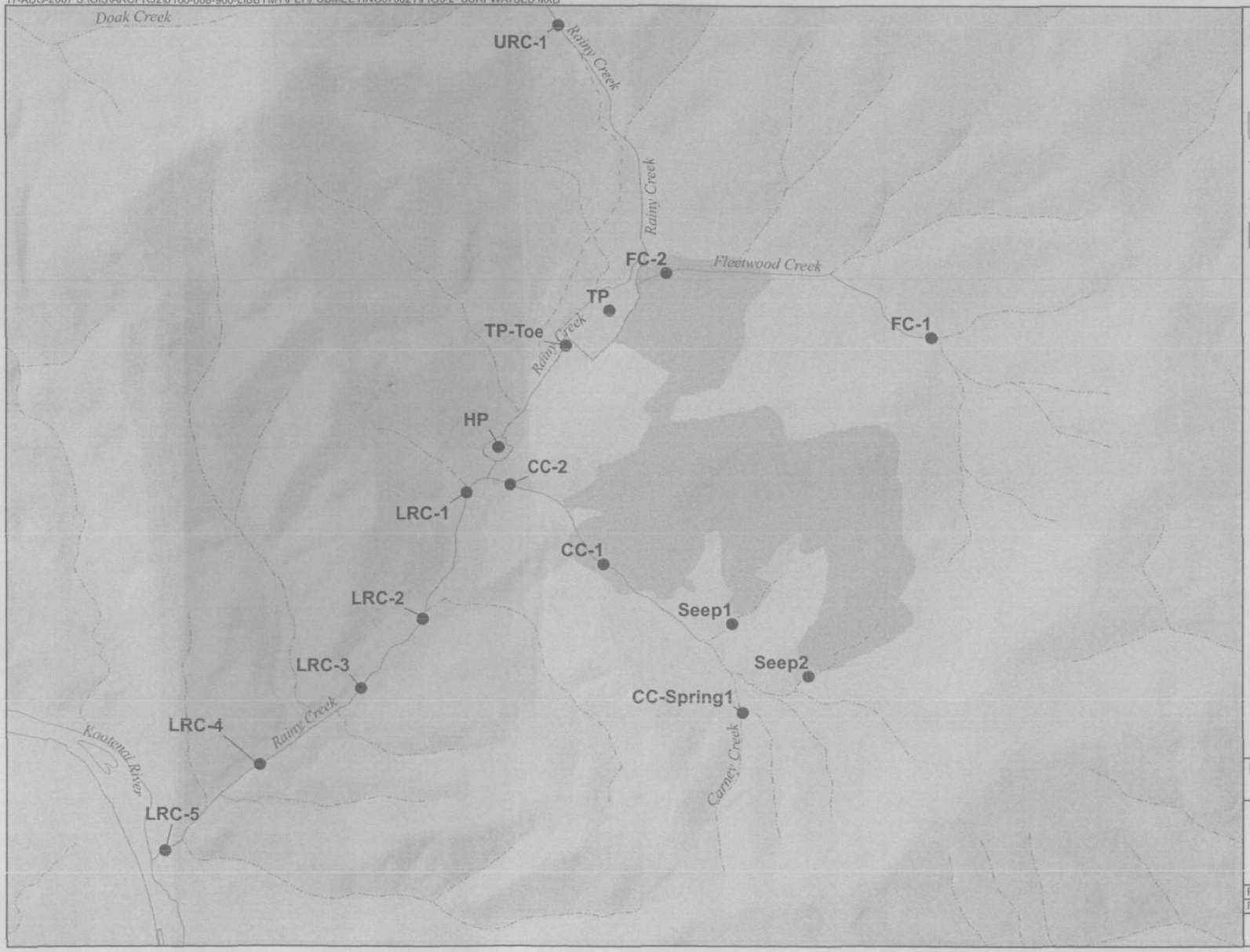
FIGURE 5-1

MINE WASTE SAMPLING LOCATIONS

PROJECT: 0100-008-900	DATE: AUG 17, 2007	
REV: 0	BY: CRL	CHECKED: AK

NEWFIELDS

17-AUG-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PUBMEETING070821\FIG5-2_SURFWATSED.MXD



Legend

- Surface Water/Sediment Sample Location
- Open Water
- Perennial Stream
- Intermittent Stream
- Mine Disturbance

DRAFT

N

0 2,000 4,000

Feet

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

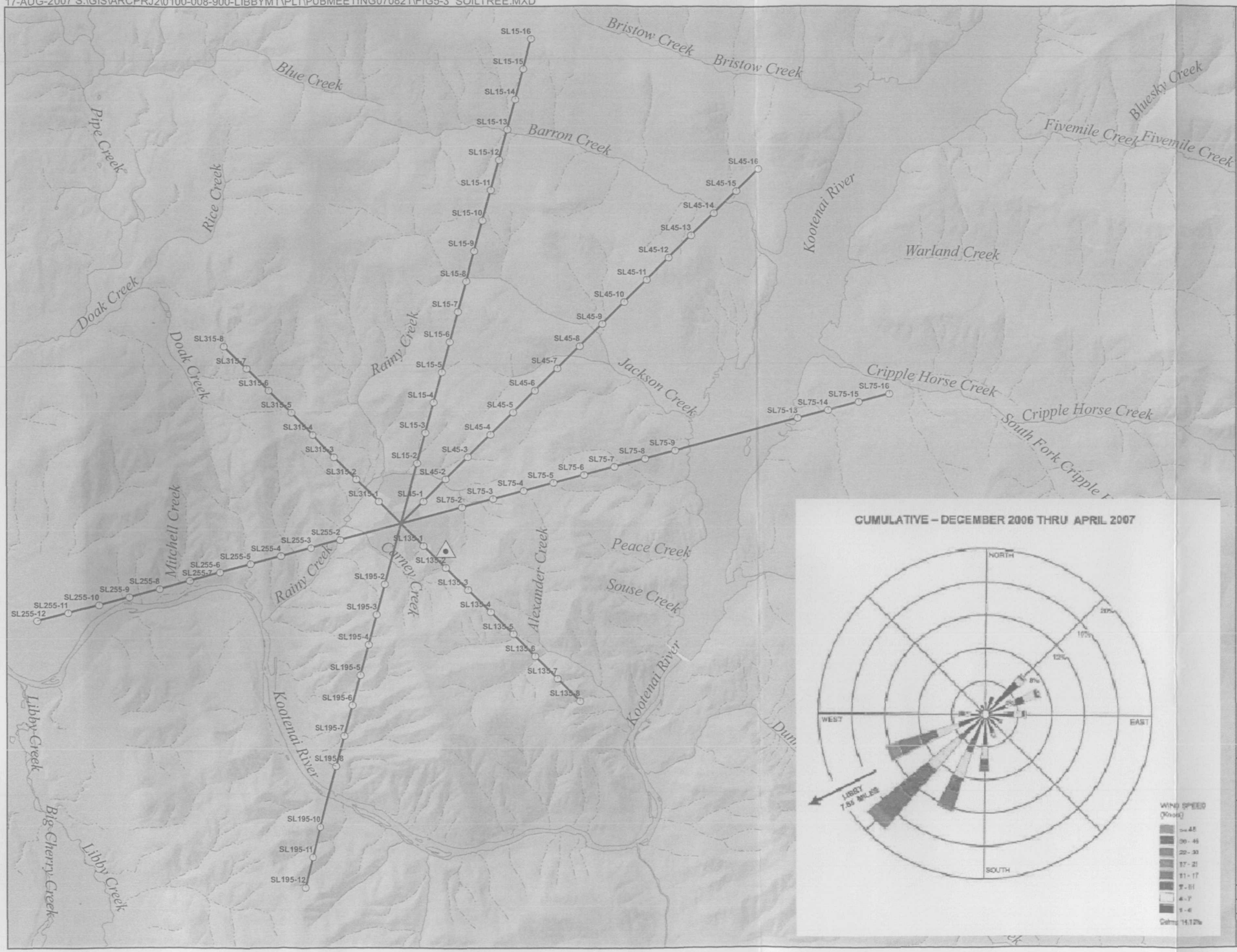
FIGURE 5-2

SURFACE WATER / SEDIMENT SAMPLING LOCATIONS

PROJECT: 0100-008-900	DATE: AUG 17, 2007	
REV: 0	BY: CRL	CHECKED: AK

NEWFIELDS

17-AUG-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PUBMEETING070821\FIG5-3_SOILTREE.MXD



CUMULATIVE – DECEMBER 2006 THRU APRIL 2007

Legend

- Open Water
- Perennial Stream
- Intermittent Stream
- Mine Disturbance
- Meterological Station
- Soil/Tree Bark Sampling Location

DRAFT

N

0 1.5 3

Miles

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

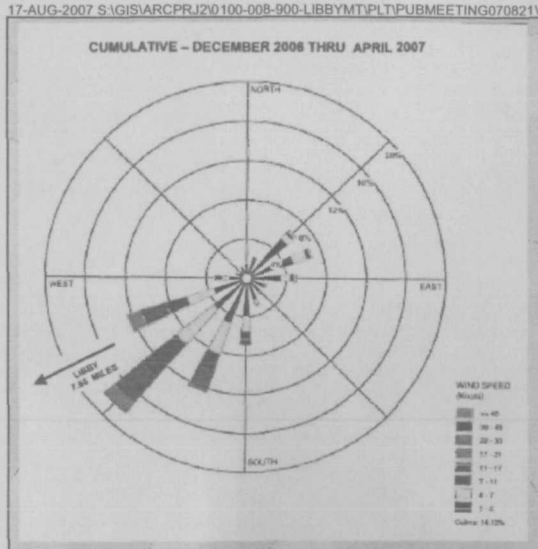
FIGURE 5-3

SOIL / TREE BARK SAMPLING LOCATIONS

PROJECT: 0100-008-900	DATE: AUG 17, 2007	
REV: 0	BY: CRL	CHECKED: AK

NEWFIELDS

17-AUG-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PUBMEETING070821\FIG5-4_AMBIENTAIR.MXD



Legend

- Open Water
- Perennial Stream
- Intermittent Stream
- Mine Disturbance
- Air Monitoring Location
- Meterological Station

DRAFT

N

0 2,000 4,000

Feet

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

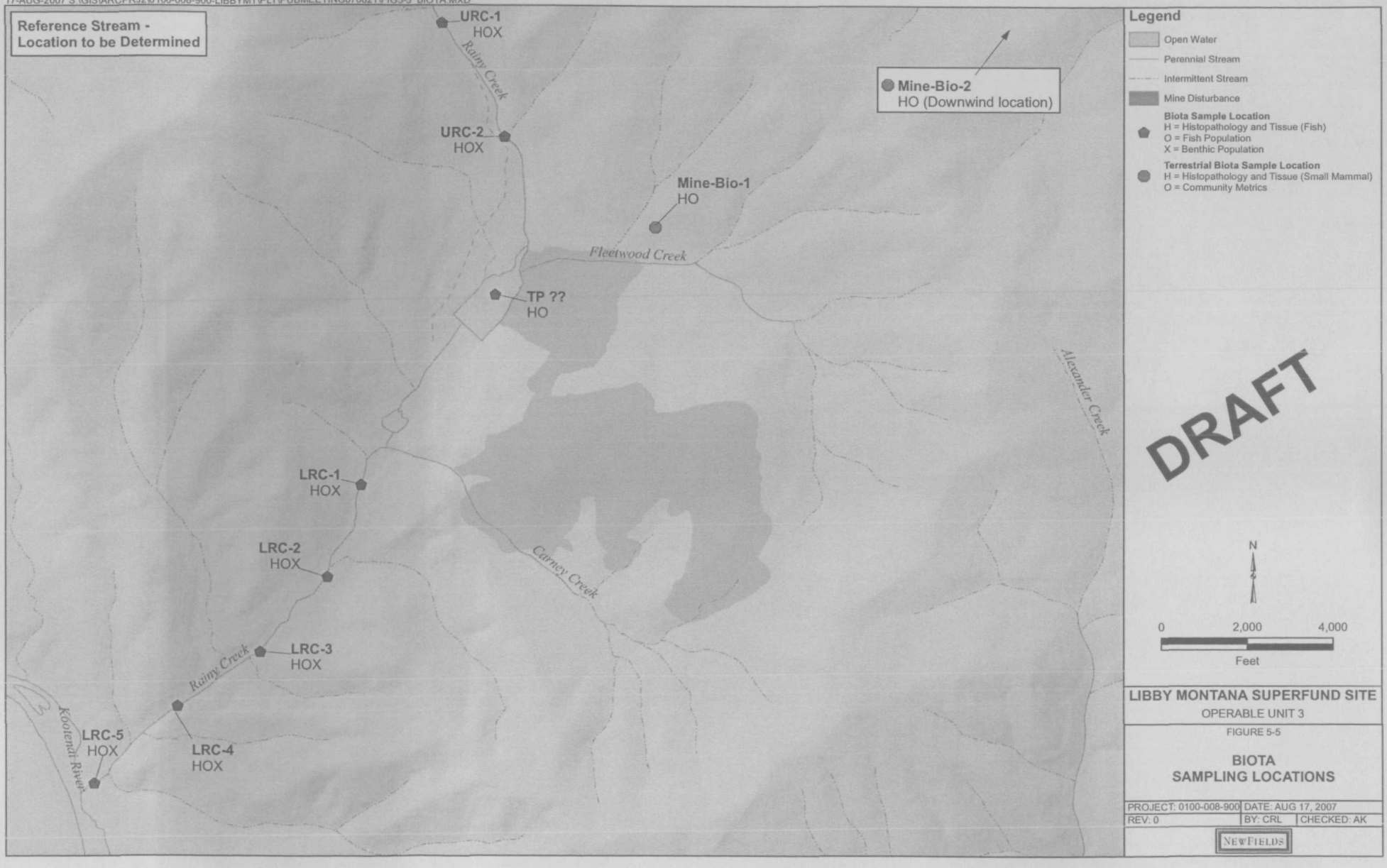
FIGURE 5-4

AIR MONITORING LOCATIONS

PROJECT: 0100-008-900	DATE: AUG 17, 2007	
REV: 0	BY: CRL	CHECKED: AK

NEWFIELDS

17-AUG-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PUBMEETING070821\FIG5-5_BIOTA.MXD



LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

FIGURE 5-5

BIOTA SAMPLING LOCATIONS

PROJECT: 0100-008-900	DATE: AUG 17, 2007	
REV: 0	BY: CRL	CHECKED: AK

NEWFIELDS

Summary of Proposed Biotic Sampling
Libby OU3 - Phase I SAP

Biota Type	Locations	Endpoint(s)
Fish	--Rainy Creek (2 upstream, 5 downstream) --Tailings Pond (?) --Reference stream (matched by elevation and habitat)	Histopathology (gill, lateral line, other?) Community Metrics (density, diversity) Tissue Burden (whole body)
Benthic Macroinvertebrates	--Rainy Creek (2 upstream, 5 downstream) --Tailings Pond (?) --Reference stream (matched by elevation and habitat)	Community Metrics (density, diversity) Habitat Assessment (RBAP)
Small Mammals	1 array of traps north of mined area 1 array of traps 4-6 miles NNE of mined area	Community Metrics (density and diversity) Histopathology (lung, GI, kidney, heart ?) Tissue Burden (target tissues)

Toxicity Data for Asbestos - Fish

Record ID	Species	Sex	Lifestage	Route of Exposure	Fiber Type	Detection Limit/Sensitivity	Exposure	Exposure Units	Duration	Endpoint	Effect	NOAEL	LOAEL	Notes
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Eggs-larvae	water	Chrysotile		0, 10^3, 10^6, 10^8, 10^{10}	f/l	13-21days	Mortality	No significant effect	10^{10}		Two exposure systems - Petri dish and aquaria; (Percent Survival 82.5-100% petri, 70-87.7% aquaria)
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Eggs-larvae	water	Chrysotile		0, 10^3, 10^6, 10^8, 10^{10}	f/l	13-21days	Days to hatch	Longer hatching times compared to controls, although delays were 1 day or less (not biologically significant)	10^{10}		Pattern not strictly dose-dependent, eggs exposed to lowest dose in petri dishes took the longest to hatch, and at 10^6 f/ml the least time
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Larvae-juvenile (<24 h old)	water	Chrysotile		0, 10^6, 10^8, 10^{10}	f/l	13 weeks	Mortality	Nearly complete mortality (98%) at 10^{10} f/l by day 42. Gradual losses in 10^6 and 10^8 dose groups	10^8	10^6	Less than 20% mortality in controls
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Larvae-juvenile (<24 h old)	water	Chrysotile		0, 10^6, 10^8, 10^{10}	f/l	13 weeks	Growth	Significant reduction in total length starting by the second week at 10^8, 10^9, and 10^{10} f/l	10^6	10^8	By day 91, controls were ~30% larger than exposed fish. Trend for growth similar to mortality
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Larvae-juvenile (<24 h old)	water	Chrysotile		0, 10^6, 10^8, 10^{10}	f/l	13 weeks	Tissue Pathology	Thickening of epidermal tissue, irregular outer cell layer ("sculpting") Partially necrotic tissue found to contain asbestos fragments	10^6	10^8	
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Larvae-juvenile (<24 h old)	water	Chrysotile		0, 10^6, 10^8, 10^{10}	f/l	13 weeks	Fiber uptake	At highest dose accumulation after only 1 month of 375.7 f/mg. At dose of 10^8 f/l after 3 months fish accumulated 486 f/mg			Authors state "asbestos uptake is implicated in reduced growth and increased mortality
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Juvenile-adult larvae	water	Chrysotile		0, 10^6, 10^8	f/l	4 months	Reproduction	No significant effect month-by-month analysis. Successful spawning and viability of eggs reduced based on a cumulative analysis		10^6	Fish were exposed for 4 months followed by a one month recovery period. Decreased spawning frequency and egg viability, although these effects were not significantly different from controls
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Juvenile-adult larvae	water	Chrysotile		0, 10^6, 10^8	f/l	4 months	Growth	No significant effect	10^8		Differences compared to juvenile larvae could be due to exposure system (76-L aquaria vs 4-L aquaria) and initial age of exposure
29770	Japanese Medaka (*Oryzias latipes*)	M/F	Juvenile-adult larvae	water	Chrysotile		0, 10^6, 10^8	f/l	4 months	Post-exposure egg survival, hatch	No significant effect	10^8		Suggests transfer from adults to offspring did not occur
27070	Amazon molly (*Poecilia formosa*)	F	2 months old	water	Chrysotile		0, 0.01, 0.1, 1, 10	mg/L	6 months	Kidney damage	Varying degrees of selective necrosis of the hemopoietic tissue, characterized by the development of "holes" or spaces. Greater in mollies exposed to fine suspensions possibly from accumulation across the intestinal mucosa.	10		Differences between fish exposed to a coarse suspension of asbestos (0.1, 1, 10 mg/L) and a fine suspension of asbestos (0.01, 0.1, 1 mg/L), due to concentration differences. Unable to assign quantitative values for extent and degree of tissue damage, except in mollies exposed to 10 mg/L of the coarse suspension. Widespread fusion of the gill lamellae and numerous aneurysms in these fish.
27070	Amazon molly (*Poecilia formosa*)	F	2 months old	water	Chrysotile		0, 0.01, 0.1, 1, 10	mg/L	6 months	Gill lesions	Aneurysms, proliferation of the gill epithelium, hypertrophy and hyperplasia of cells at the base of the secondary lamellae, fusion of lamellae	1	10	
27070	Amazon molly (*Poecilia formosa*)	F	2 months old	water	Chrysotile		0, 0.01, 0.1, 1, 10	mg/L	6 months	Heart lesions	No significant effect	10		
16930	Coho salmon (*Oncorhynchus kisutch*)	M/F	Larvae	water	Chrysotile	Not reported	0, 1.50E-06, 3.00E-06	f/l	40-86 days	Mortality	No significant effect	3.00E+06		Based on levels of chrysotile exposures approximating those reported in the Great Lakes basin (1e+06 f/l)
16930	Coho salmon (*Oncorhynchus kisutch*)	M/F	Larvae	water	Chrysotile	Not reported	0, 1.50E-06, 3.00E-06	f/l	40-86 days	Behavioral effects	Loss of rheotaxic position and balance in the high dose group	1.50E+06	3.00E+06	Fish found laying on their sides in the bottom of the tank by day 13, by day 20 nearly all fish were displaying this behavior. Prodding with glass rods induced erratic swimming movements, characterized by tight spirals and returning to rest on the bottom
16930	Coho salmon (*Oncorhynchus kisutch*)	M/F	Larvae	water	Chrysotile	Not reported	0, 1.50E-06, 3.00E-06	f/l	40-86 days	Histopathology	Distortion of the lateral line regions and cellular histolysis resulting in eroding of the epidermis. Extensive vacuolization of cells along the ventrum. Two fish developed tumorous swellings, and three additional fish developed coelomic distentions	1.50E+06	3.00E+06	Evidence of the presence of asbestos in larvae using TEM. Lateral line organs are essential in orientational ability, maintenance of equilibrium, and acts as a major recipient of environmental information in fish. All controls displayed normal development and configuration of the lateral line.
16930	Coho salmon (*Oncorhynchus kisutch*)	M/F	Larvae	water	Chrysotile	Not reported	0, 1.50E+06, 3.00E+06	f/l	40-86 days	Stress test (exposed to TMS)	Ataxic and loss of equilibrium faster than controls.		1.50E+06	Study measured susceptibility to tricaine methanesulfonate (TMS) anesthesia in asbestos treated fish
16930	Coho salmon (*Oncorhynchus kisutch*)	M/F	Larvae	water	Chrysotile	Not reported	0, 1.50E-06, 3.00E-06	f/l	40-86 days	Growth	No significant effect	3.00E+06		Average total lengths of control and treated fish were not significantly different. Authors declare the results of the anesthetic response attributable to exposure or lack of exposure to asbestos, and not to differences in body size.
16930	Green sunfish (*Lepomis cyanellus*)	M/F	Juvenile	water	Chrysotile	Not reported	0, 1.50E-06, 3.00E-06	f/l	52-67 days	Mortality	No significant effect	3.00E+06		
16930	Green sunfish (*Lepomis cyanellus*)	M/F	Juvenile	water	Chrysotile	Not reported	0, 1.50E-06, 3.00E-06	f/l	52-67 days	Histology	Loss of scales and skin surface tissues	1.50E+06	3.00E+06	

Toxicity Data for Asbestos -Aquatic Invertebrates
(Page 1 of 2)

Reference	Study ID	Species	Sex	Lifestage	Route of Exposure	Fiber Type	Exposure(s)	Exposure Units	Duration	Endpoint	Effect	NOAEL	LOAEL	Notes	Analysis	Detection Limits/Sensitivity	Length Distributions	Width Distributions
Belanger et al 1986	40520	Asiatic clam (*Corbicula fluminea*)	NR	Adult	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7	f/l	96 hours	Behavior	Without food: decreased siphoning at 48 hours, by 72 hours at 1/3 control levels With food: No significant difference from controls	10^6			TEM	1.79E-04 - 6.91E-04 f/l	NR	NR
Belanger et al 1986	40520	Asiatic clam (*Corbicula fluminea*)	NR	Adult	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^8	f/l	14 days	Reproduction	Significant increases in mortality of larvae and decreases in larvae released from adults exposed to 10^4-10^8 f/ml		10^4		TEM	1.79E-04 - 6.91E-04 f/l	NR	NR
Belanger et al 1986	40520	Asiatic clam (*Corbicula fluminea*)	NR	Adult	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^8	f/l	30 days	Behavior	Decreased siphoning activity in all exposure groups		10^4		TEM	1.79E-04 - 6.91E-04 f/l	NR	NR
Belanger et al 1986	40520	Asiatic clam (*Corbicula fluminea*)	NR	Adult	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^8	f/l	30 days	Growth	Decreased growth and decreased shell length in all exposure groups		10^4		TEM	1.79E-04 - 6.91E-04 f/l	NR	NR
Belanger et al 1986	40520	Asiatic clam (*Corbicula fluminea*)	NR	Adult	Water	Chrysotile	0 10^4, 10^5, 10^6, 10^8	f/l	30 days	Gill ultrastructural changes	Increased number of locules in each lamella ($p<0.005$), and locules occupied significantly greater surface area.		10^5	Only clams exposed to 10^8 f/ml were examined for gill changes.	TEM	1.79E-04 - 6.91E-04 f/l	NR	NR
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Behavior	Decreased siphoning activity in all asbestos exposures relative to controls except 10^4 f/l in summer ($p<0.05$)	10^5	10^6	Clams were collected and studied to compare seasonal differences (winter and summer). Controls mean siphoning activity of 70.8%, while exposed clams ranged from 53.1% (10^6 f/l) to 64.7% (10^5 f/l)	TEM	< 10^4 f/l	NR	NR
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Growth	Significantly less shell and tissue growth at 10^6 f/l and above	10^5	10^6	Relative shell growth tissue growth (mm/mg) greater in summer than winter	TEM	< 10^4 f/l	NR	NR
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Mortality	No significant effect	10^8		2/120 (1.7%) died at highest exposure in summer. No mention of control survival	TEM	< 10^4 f/l	NR	NR
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Gill ultrastructural changes	Increased size and surface area of locules in the gill at the highest exposure		10^8	Control clams possed gill lamellae in which locules accounted for 14.7 +/- 3.1% of total surface area. Summer exposed clams accounted for 23.1 +/- 3.5%	TEM	< 10^4 f/l	NR	NR
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Fiber Accumulation	Fibers accumulated in gill and visceral tissue in clams exposed to 10^8 f/l. Fiber burdens ~ 10X greater in viscera (1100 f/mg) than gill tissue (150 f/mg)			Control and 10^4 f/l groups were below detection limits. Authors state that fiber accumulations in gill tissue are reflected in deteriorated gill tissue and greater tissue water content in asbestos exposed clams	TEM	< 10^4 f/l	Gills: 0.715 um - 0.832 um. Viscera: 1.977 um - 3.319 um. all significantly	Gills: 0.059 um - 0.099 um. Viscera: 0.292 um - 0.338 um; Viscera
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Behavior	Decreased siphoning activity in all asbestos exposures relative to controls in winter ($p<0.05$)		10^5	Clams were collected and studied to compare seasonal differences (winter and summer). Controls mean siphoning activity of 74.8%, while exposed clams ranged from 50.3% (10^5 f/l) to 65.8% (10^6 f/l)	TEM	< 10^4 f/l	Not reported	Not reported
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Growth	Significantly less weight gain at 10^6 f/l and above	10^5	10^6	Clams exposed to 10^8 f/l and above in winter had reduced shell and weight growth, however, only weight gain was significantly altered at 10^6 f/l compared to controls	TEM	< 10^4 f/l	Not reported	Not reported
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Mortality	No significant effect	10^8		3/60 (5%) died at highest exposure in winter. No mention of control survival	TEM	< 10^4 f/l	Not reported	Not reported
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Gill ultrastructural changes	Increased size and surface area of locules in the gill at the highest exposure		10^8	Control clams possessed gill lamellae in which locules accounted for 16.7 +/- 4.2% of total surface area. Summer exposed clams accounted for 27.6 +/- 7.2%	TEM	< 10^4 f/l	Not reported	Not reported
Belanger et al 1986	17290	Asiatic clam (*Corbicula fluminea*)	NR	Juvenile	Water	Chrysotile	0, 10^4, 10^5, 10^6, 10^7, 10^8	f/l	30 days	Fiber Accumulation	Fibers accumulated in gill and visceral tissue in clams exposed to 10^8 f/l. Fiber burdens ~ 10X greater in viscera (1100 f/mg) than gill tissue (150 f/mg)			Control and 10^4 f/l groups were below detection limits	TEM	< 10^4 f/l	Not reported for winter exposures	Not reported for winter exposures
Stewart and Schurr 1980	40420	Brine shrimp (*Artemia sp.*)	F	Larvae (3 days old)	Water	Chrysotile	1.2e+08, 2.4e+08, 4.8e+08, 9.6e+08, +11	f/l	24 hours	Mortality	Significant decrease in survival in all exposure groups compared to controls		2.40E+08	No significant difference between mortality among the exposure groups. Authors state that it is unclear if the cause of death is due to clogging of the filter feeding mechanism or ingestion of asbestos (applicable across all exposures)	SEM	Not reported	"Short fiber chrysotile" (Fiber length frequency plotted in Figure	Not reported
Stewart and Schurr 1980	40420	Brine shrimp (*Artemia sp.*)	F	Larvae (3 days old)	Water	Chrysotile	6.1E+07, 1.2e+08, 2.4E+08, 4.8E+08	f/l	24 hours	Mortality	Decrease in survival in all exposure groups compared to controls. Authors do not discuss significance			In comparison to 3-day short chrysotile tests, no significant differences	SEM	Not reported	"Medium fiber chrysotile" (Fiber length	Not reported

Toxicity Data for Asbestos - Mammals
(Page 1 of 2)

Record ID	Common Name	Sex	Lifestage	Route of Exposure	Fiber Type	Exposure(s)	Exposure Units	Duration	Endpoint	Effect	NOAEL	LOAEL	Notes	Analysis	Counting Rules	Length Distributions	Width Distributions
15510	Mouse (ICR)	F	Adult - pregnant	Gavage (saline vehicle)	Chrysotile	0, 50	ug/org	4 days	Litter size	No effect	50		10 pups/litter treated; 11 pups/litter control	SEM - EDXA	Not reported	Not reported	
15510	Mouse (ICR)	F	Adult - pregnant	Gavage (saline vehicle)	Chrysotile	0, 50	ug/org	4 days	Growth of pups	No significant effect	50		Treated pups demonstrated decreased weight gain compared to controls, but the difference was not significant	SEM - EDXA	Not reported	Not reported	
15510	Mouse (ICR)	F	Adult - pregnant	Gavage (saline vehicle)	Chrysotile	0, 50	ug/org	4 days	Pup mortality	No significant effect	50		Postnatal fetal mortality higher in treated group, 5.61 pups (8.2%) died versus 3.66 (4.5%) pups from the control group	SEM - EDXA	Not reported	Not reported	
15510	Mouse (ICR)	F	Adult - pregnant	Gavage (saline vehicle)	Chrysotile	0, 50	ug/org	4 days	Transplacental fiber uptake by pups	Detectable fibers in lungs and livers of pups from exposed adult mice			Body burden	SEM - EDXA	Not reported	Not reported	Not reported
10460	Rat (Sprague-Dawley)	NR	Weanling	Diet	Chrysotile and Amosite	0, 20	mg rat-day	870 days	Tumor incidence	Seven rats developed malignant tumors (carcinoma, fibrous histiocytoma, lymphoma, and one mesothelioma). 15 developed benign breast fibroadenomas. Cancer frequency is not significantly greater than controls.		20	No report of gastrointestinal cancer. 5 mg/g cheese per day (Low Dose Chrysotile first 7 months, amosite for remainder). Departure from null hypothesis of no difference are not statistically significant at the 5% level ($0.225 < P < 0.5$) by $X2$ ($N = 30$)	Electron Microscopy (USEPA)	Not reported	Not reported	Not reported
10460	Rat (Sprague-Dawley)	NR	Weanling	Diet	Chrysotile and Amosite	0, 300	mg rat-day	750 days	Tumor incidence	One rat developed leukemia, ten rats developed breast fibroadenomas, and one rat developed leiomyoma		300	No report of gastrointestinal cancer. 50 mg/g cheese per day (High Dose - amosite only). Departure from null hypothesis of no difference are not statistically significant at the 5% level ($0.225 < P < 0.5$) by X2 ($N=20$)	Electron Microscopy (USEPA)	Not reported	Not reported	Not reported
18390	Rat (Sprague-Dawley)	Male	NR	Drinking water	Chrysotile	0.5	g/l - day	1.5 years	Growth	No significant effect	0.5		Initial weight: 150 - 200 g Final weight: Controls - 368 g; Treated - 353 g	Not reported	Not reported	Not reported	Not reported
18390	Rat (Sprague-Dawley)	Male	NR	Drinking water	Chrysotile	0.5	g/l - day	1.5 years	Intestinal permeability	Decreased absorption of some non-metabolizable sugars (lactulose and mannitol)		0.5	Suggested by authors that may indicate that asbestos blocked the usual route for penetration of these compounds. Absorption of rhamnose: no significant effect	Not reported	Not reported	Not reported	Not reported
18390	Rat (Sprague-Dawley)	Male	NR	Drinking water	Chrysotile	0.5	g/l - day	1.5 years	Kidney Function	No significant effect	0.5		No difference in the clearance of creatine suggests that the asbestos treatment did not cause impairment of kidney function	Not reported	Not reported	Not reported	Not reported
8610	Rat (Fisher F344 and Holtzman)	Male	Weanling (Fisher) and adult (Holtzman)	Diet	Chrysotile	0, 10	percent weight/ weight basis	350 days	Tumor incidence (Colon)	Two rats developed adenocarcinomas, one rat developed a sarcoma. Not a significant difference in tumor rates with the control group			No tumors seen in the control group, but the authors state that the combined fiber groups (asbestos and cellulose) were not significantly different from the standard diet group. Study evaluates effect of asbestos fed rats treated with X-irradiation. Adenocarcinomas developed in localized areas of x-ray treatment. Other lesions of the colon documented. Ten rats demonstrated no lesions	Not reported	Not reported	Not reported	Not reported
40390	Rat (Wistar)	NR	NR	Gavage	Amosite	100	mg rat-day	5 days	Pathology	No significant effect	100		No evidence of macrophage response or other pathological changes in the small intestine. No mention of controls. "	Light microscopy (no further detail)	Not reported	Not reported	Not reported
40390	Rat (Wistar)	NR	NR	Gavage (corn oil)	Amosite	0, 100 (+25)	mg-rat-day	2 days	Transmigration in regions of ulceration of the GI tract	No intracellular fibers observed in areas of the GI tract with visible ulcerations	100		Rats received 100 mg amosite daily by gavage for 2 days, on the third day, 10 mg/kg indomethacin was administered to induce ulcers. The asbestos treated rats received a further 25 mg dose of amosite on the same day and daily thereafter until they were killed. Authors suggest the gut wall of rats may present an effective barrier to the penetration of asbestos even under conditions of epithelial loss. Limitations in exposure duration, no histological examination of macrophages	PLM	Not reported	Not reported	Not reported
11180	Hamster (Golden Syrian)	M F	Juveniles (2 months old)	Drinking water (continuous flow of air bubbles)	Amosite	0, 130, 1300, 13000	millions of fibers/liter - day	Lifetime	Mortality	No significant effect	13,000		Median survivorship of males was 448 days, for females was 391 days. For males and separately for females in each treatment group, median survival times at 95% CI on enlapped controls	TEM/SEM	Not reported	Measurements by SEM at x600 as reported in Record	Not reported
11180	Hamster (Golden Syrian)	M F	Juveniles (2 months old)	Drinking water (continuous flow of air bubbles)	Amosite	0, 130, 1300, 13000	millions of fibers/liter - day	Lifetime	Growth	No significant effect	13,000		Differences in body weight are inconclusive, since they are neither dose-related nor treatment-related	TEM/SEM	Not reported	Measurements by SEM at x600 as reported in Record	Not reported
11180	Hamster (Golden Syrian)	M F	Juveniles (2 months old)	Drinking water (continuous flow of air bubbles)	Amosite	0, 130, 1300, 13000	millions of fibers/liter - day	Lifetime	Tumor incidence	Not a significant difference in tumor rates from controls	13,000		A peritoneal mesothelioma, pulmonary carcinoma and two early squamous cell carcinoma of the forestomach were found in exposed hamsters. The tumors could not be specifically attributed to amosite	TEM/SEM	Not reported	Measurements by SEM at x600 as reported	Not reported
5930	Rat (Wistar Han SPF)	M F	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile	0, 10, 60, 360	mg/day	24 months	Survival	No significant effect	360		By the end of the experiment there were high numbers of rats with tumors, both controls and exposed rats N = 68-70 per exposure group (including control group)	NR	Not reported	Not reported	Not reported
5930	Rat (Wistar Han SPF)	M F	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile	0, 10, 60, 360	mg/day	24 months	Growth	No significant effect	360			NR	Not reported	Not reported	Not reported
5930	Rat (Wistar Han SPF)	M F	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile	0, 10, 60, 360	mg/day	24 months	Tumor incidence	No significant effect	360			NR	Not reported	Not reported	Not reported
5930	Rat (Wistar Han SPF)	M F	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile (75%) Crocidolite (25%) mixture	0, 10, 60, 360	mg/day	24 months	Survival	No significant effect	360			NR	Not reported	Not reported	Not reported
5930	Rat (Wistar Han SPF)	M F	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile (75%) Crocidolite (25%) mixture	0, 10, 60, 360	mg/day	24 months	Growth	No significant effect	360			NR	Not reported	Not reported	Not reported

Toxicity Data for Asbestos - Mammals
(Page 2 of 2)

Record ID	Common Name	Sex	Lifestage	Route of Exposure	Fiber Type	Exposure(s)	Exposure Units	Duration	Endpoint	Effect	NOAEL	LOAEL	Notes	Analysis	Counting Rules	Length Distributions	Width Distributions
5930	Rat (Wistar Han SPF)	M/F	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile (75%)/ Crocidolite (25%) mixture	0, 10, 60, 360	mg/day	24 months	Tumor incidence	No significant effect	360			NR	Not reported	Not reported	Not reported
2630	Hamster (Golden Syrian)	M	13-15 weeks old	Aerosol (nose-only inhalation chambers)	Amosite (low)	0, 25, 125, 250	WHO f'ce	12 months	Mortality	No significant effect	250		Mortality study was compromised by an infectious disease diagnosed as wet tail (increased mortality during weeks 17 to 26) Treatment of hamsters with tetracycline After the 26-week time point, mortality rates returned to levels similar to previous hamster studies	SEM	AR ≥3:1, W ≥ 3 um, L > 5 um	Low = 13.7 +/- 17.0 um, Medium = 12.5 +/-	Low = 0.60 +/- 0.24 um, Medium = 0.58 +/- 0.24 um, High =
2630	Hamster (Golden Syrian)	M	13-15 weeks old	Aerosol (nose-only inhalation chambers)	Amosite (low)	0, 25, 125, 250	WHO f'ce	12 months	Growth	No significant effect	250		Average body weights did not differ from sham-exposed controls	SEM	AR ≥3:1, W ≥ 3 um, L > 5 um	Low = 13.7 +/- 17.0 um, Medium = 12.5 +/-	Low = 0.60 +/- 0.24 um, Medium = 0.58 +/- 0.24 um, High =
2630	Hamster (Golden Syrian)	M	13-15 weeks old	Aerosol (nose-only inhalation chambers)	Amosite (low)	0, 25, 125, 250	WHO f'ce	12 months	Lung Weights	Significantly increased compared to controls for the mid- and high dose groups	25	125	After 13 and 52 weeks of inhalation, mid and high dose groups demonstrated significantly elevated lung weights compared to the air controls	SEM	AR ≥3:1, W ≥ 3 um, L > 5 um	Low = 13.7 +/- 17.0 um, Medium = 12.5 +/-	Low = 0.60 +/- 0.24 um, Medium = 0.58 +/- 0.24 um, High =
2630	Hamster (Golden Syrian)	M	13-15 weeks old	Aerosol (nose-only inhalation chambers)	Amosite (low)	0, 25, 125, 250	WHO f'ce	12 months	Histopathology	Bronchiolization, macrophages, neutrophils, mesothelial hyperplasia and hypertrophy, and many well-defined microgranulomas (some containing fibers) at the low dose Severity increased at the mid- and high dose groups High dose group also demonstrated hepatization		25	WHO fiber lung burdens showed time-dependent and dose-dependent increases Severity of adverse lung effects increased with time and with dose	SEM	AR ≥3:1, W ≥ 3 um, L > 5 um	Low = 13.7 +/- 17.0 um, Medium = 12.5 +/- 16.0 um, High =	Low = 0.60 +/- 0.24 um, Medium = 0.58 +/- 0.24 um, High = 0.59 +/- 0.24 um (arithmetic
11510	Rat (Fisher F344)	M/F	Weanling	Diet	Chrysotile	0, 10 % of diet	percentage of diet	32 months	Colon histopathology	Four tumors in the exposed rats, two tumors in the control rats. One mesothelioma in exposed rats. Non-neoplastic lesions were reported but frequency was not significantly different from control			Actuarial analysis demonstrated that asbestos-fed rats were eventually at a greater risk for lesions (17.9%) compared to controls (8.2%)	NR	NR	Not reported	Not reported
11510	Rat (Fisher F344)	M/F	Weanling	Diet	Chrysotile	0, 10 % of diet	percentage of diet	32 months	Cellular function	Significantly decreased cAMP levels compared to the controls			Authors suggest this indicates a senescent, cell-regulator defect related to asbestos ingestion	NR	NR	Not reported	Not reported
12450	Rat (Wistar)	M	Weanling	Diet (corn oil)	Chrysotile	0, 1% of diet	percentage of diet	Lifetime	Growth	Decreased growth rate in the first 6 weeks of exposure Differences in weight from controls was maintained for several weeks and then the weight of the treated rats gradually approached that of the controls.		1	Two experiments 1 used 10 rats/group, 1 used 20 rats/group.	Electron Microscopy (not specified)	NR	0.3-10 um 49% 3 1-5.0 um 9% 5 1-10 um 10% 10 1-50 um 10%	Not reported

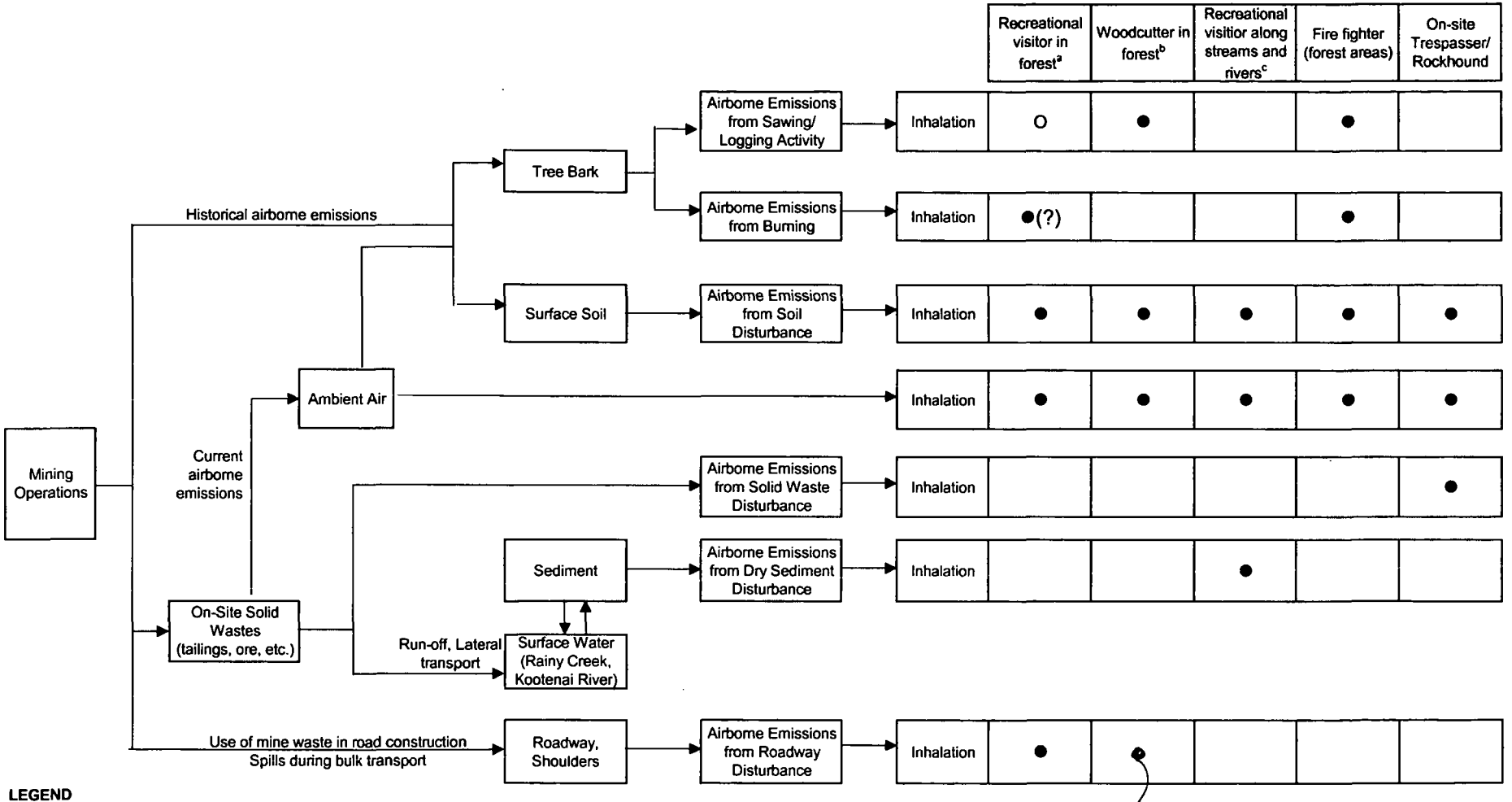
Toxicity Data for Asbestos -Aquatic Invertebrates
(Page 2 of 2)

Reference	Study ID	Species	Sex	Lifestage	Route of Exposure	Fiber Type	Exposure(s)	Exposure Units	Duration	Endpoint	Effect	NOAEL	LOAEL	Notes	Analysis	Detection Limits/Sensitivity	Length Distributions	Width Distributions
Stewart and Schurr 1980	40420	Brine shrimp (*Artemia sp.*)	F	Larvae (3 days old)	Water	Chrysotile	2.2E+07, 4.4E+07, 8.9E+07, 1.8E+08	f/l	24 hours	Mortality	Decrease in survival in all exposure groups compared to controls. Authors do not discuss significance			In comparison to 3-day short chrysotile tests, only significant difference was for the 200 mg/l long fiber chrysotile concentration.	SEM	Not reported	"Long fiber chrysotile" (Fiber length frequency	Not reported
Stewart and Schurr 1980	40420	Brine shrimp (*Artemia sp.*)	F	Larvae (2 days old)	Water	Chrysotile	1.2e+08, 2.4e+08, 4.8e+08, 9.6e+08	f/l	24 hours	Mortality	Significant decrease in survival in all exposure groups compared to controls		2.40E+08	Mean survival rates are higher than those for the 3-day old *Artemia*. A significant increase in survival is seen at all levels of asbestos concentrations except for the highest one compared to the 3-day old tests	SEM	Not reported	"Short fiber chrysotile" (Fiber length frequency plotted in Figure	Not reported
Stewart and Schurr 1980	40420	Brine shrimp (*Artemia sp.*)	F	Larvae (3 days old)	Water	Crocidolite	4.4E+07, 8.8E+07, 1.7E+08, 3.5E+08	f/l	24 hours	Mortality	No significant effect	3.50E+08		Crocidolite allows a higher survival rate, although authors note that the crocidolite did not mix in the water as well as the chrysotile, as it tended to stay either at the top or bottom. In comparison to 3-day short chrysotile tests, significant differences in the 200 and 400 mg/l exposure groups only	SEM (X-ray diffraction)	Not reported	"Short fiber amphibole" (Fiber length frequency plotted in Figure 4)	Not reported

NR = Not reported.

Site Conceptual Model for Human Exposure to Asbestos

Operable Unit 3, Libby Superfund Site, Libby, Montana



LEGEND

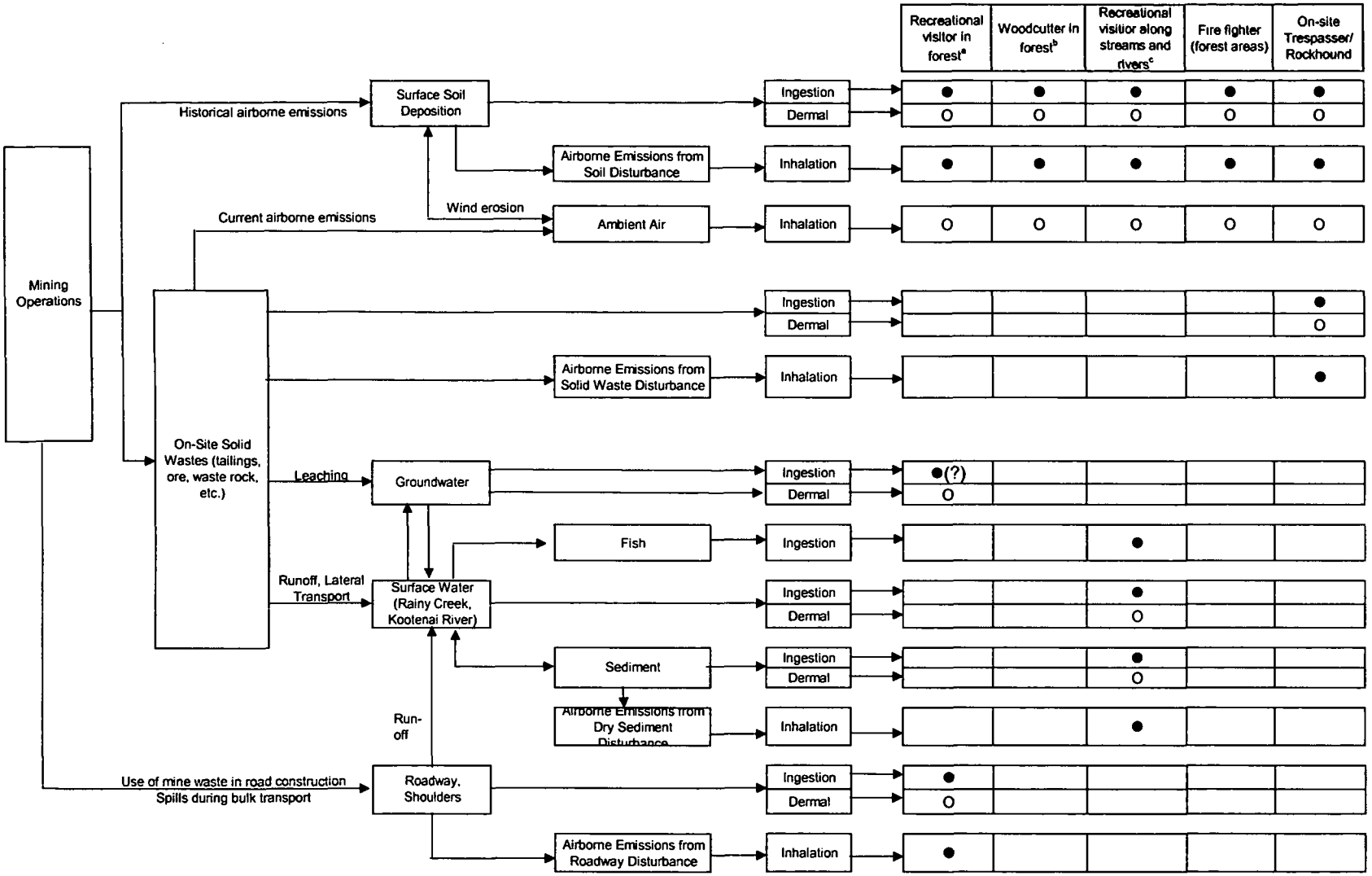
●	Pathway is complete and exposure may be significant; quantitative evaluation is warranted
O	Pathway is complete but is believed to be minor in comparison to other pathways; qualitative evaluation is warranted
	Pathway is incomplete or believed to be negligible; further evaluation is not warranted

NOTES:

a. Recreational visitors in forest areas may include a range of activities, such as camping, hiking, dirt bike or ATV riding, hunting, etc.
b. Woodcutting may include exposures of area residents gathering wood for personal use as well as commercial logging activities
c. Recreational visitors along streams and rivers may include a range of activities such as hiking, fishing and wading/swimming — ATV RIDING, HUNTING,

Site Conceptual Model for Human Exposure to Non-Asbestos Contaminants

Operable Unit 3, Libby Superfund Site, Libby, Montana



LEGEND

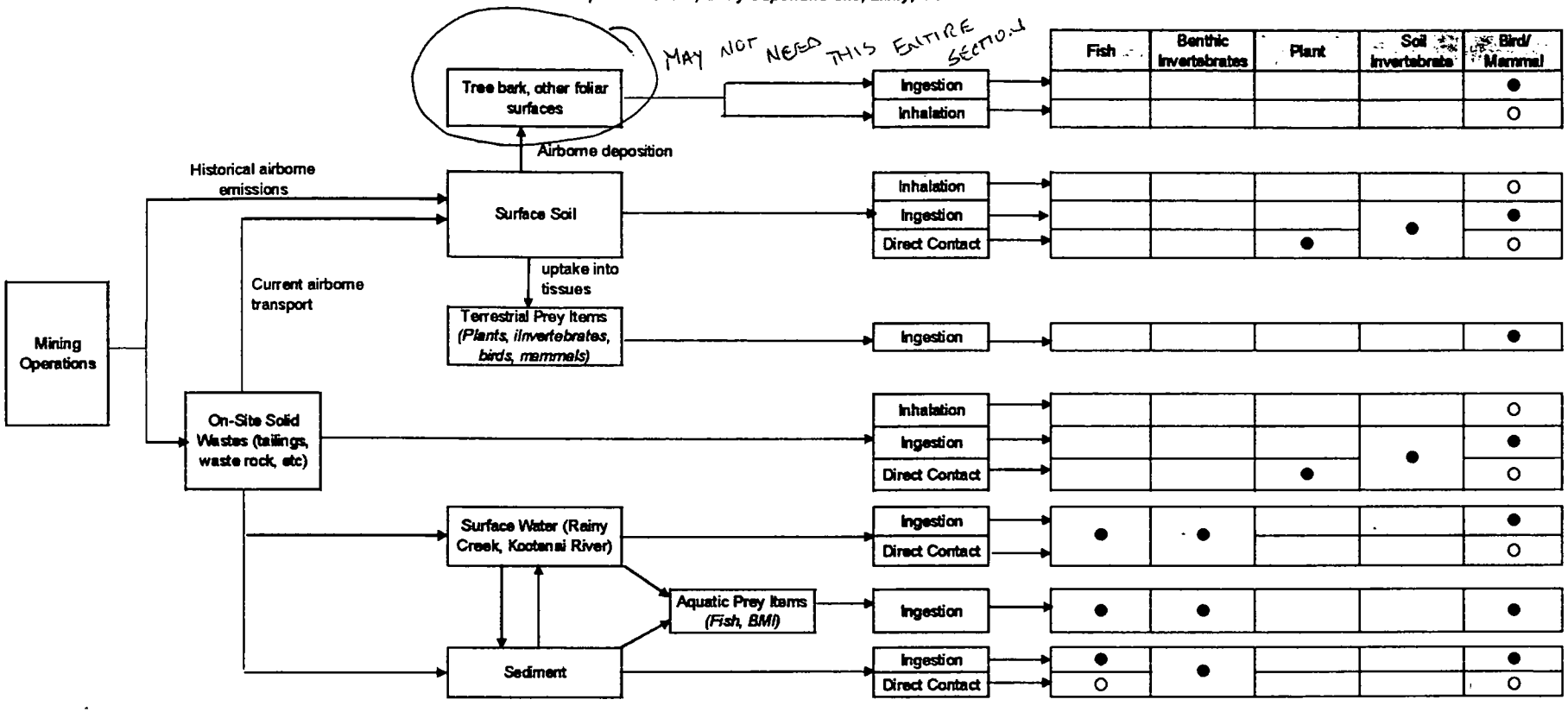
●	Pathway is complete and exposure may be significant; quantitative evaluation is warranted
O	Pathway is complete but is believed to be minor in comparison to other pathways; qualitative evaluation is warranted
	Pathway is incomplete or believed to be negligible; further evaluation is not warranted

NOTES:

a. Recreational visitors in forrest areas may include a range of activities, such as camping, hiking, dirt bike or ATV riding, hunting, etc.
b. Woodcutting may include exposures of area residents gathering wood for personal use as well as commercial logging activities
c. Recreational visitors along streams and rivers may include a range of activities such as hiking, fishing and wading/swimming

Site Conceptual Model for Ecological Exposure to Non-Asbestos Contaminants

Operable Unit 3, Libby Superfund Site, Libby, Montana

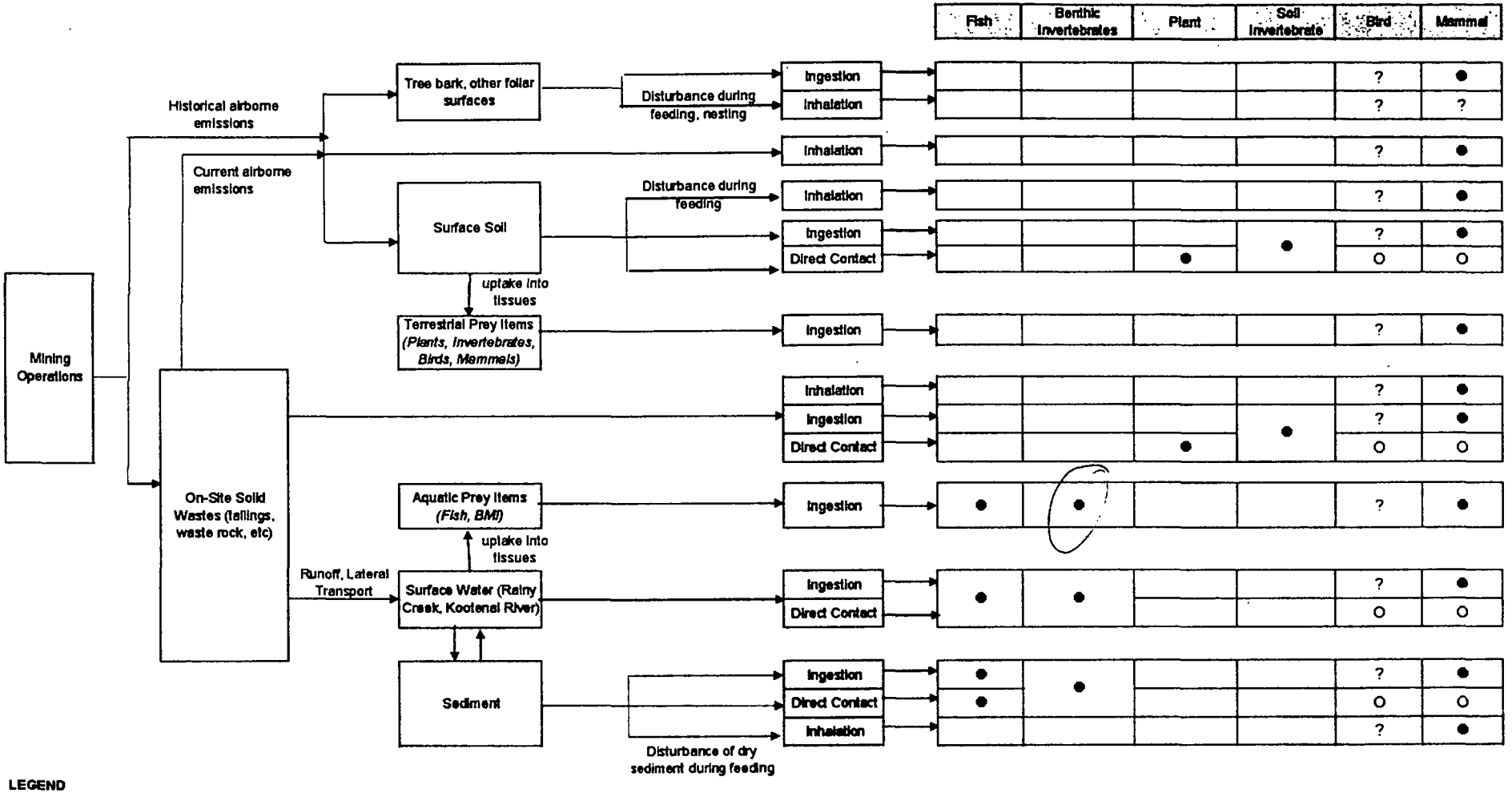


LEGEND

●	Pathway is believed to be complete, and which may provide an important contribution to the total risk to the receptor. Quantitative evaluation will be performed using one or more lines of evidence.
O	Pathway is believed to be complete but is unlikely to be a major contributor to the total risk to the receptor (in comparison to one or more other pathways that are evaluated). Pathway will not be evaluated quantitatively.
	Pathway is not believed to be occurring (now or in the future). This pathway is not evaluated.
?	Pathway that is or might be complete, but data are not adequate to decide if it is a major contributor to the total risk of the receptor.

Site Conceptual Model for Ecological Exposure to Asbestos

Operable Unit 3, Libby Superfund Site, Libby, Montana



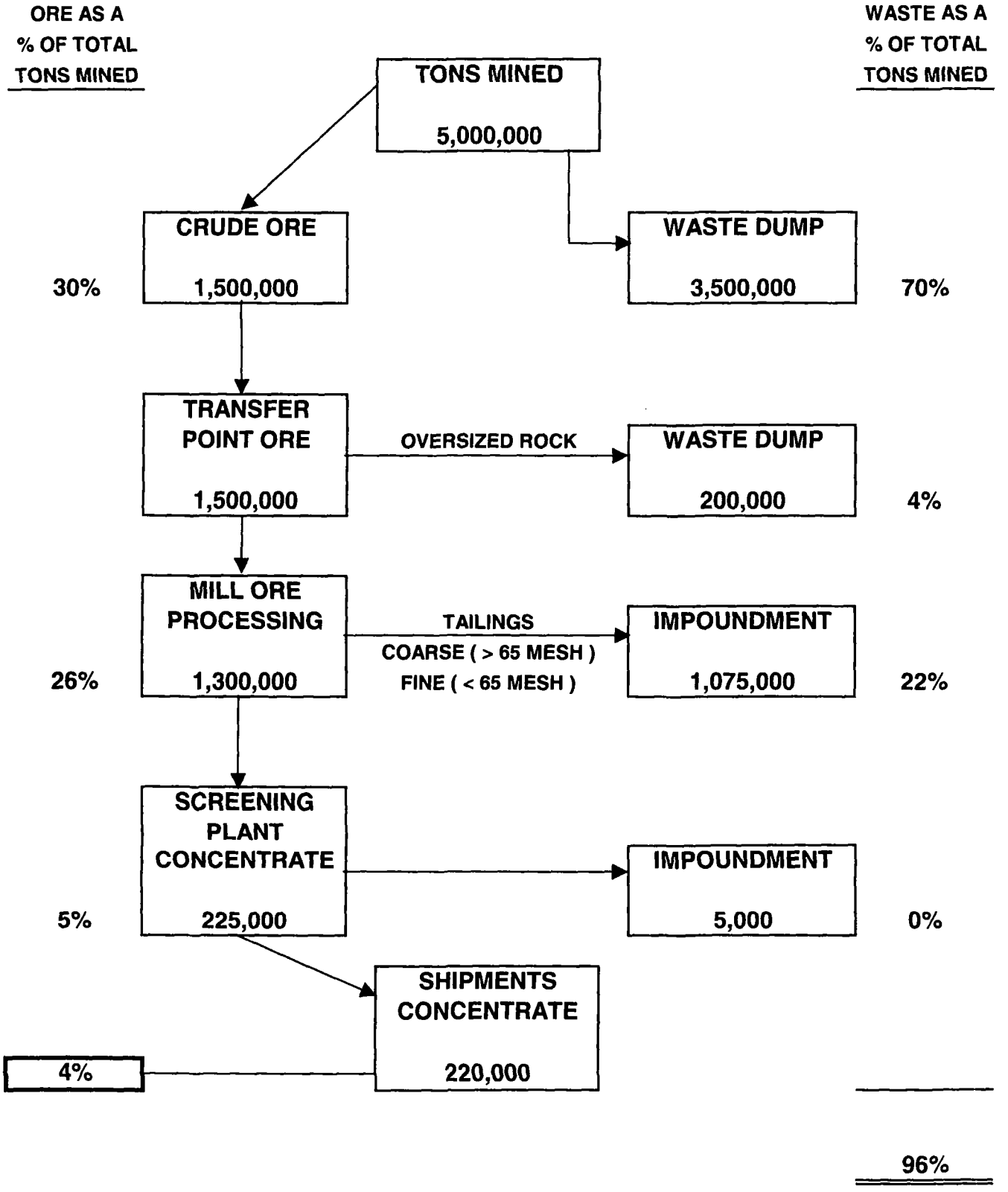
LEGEND

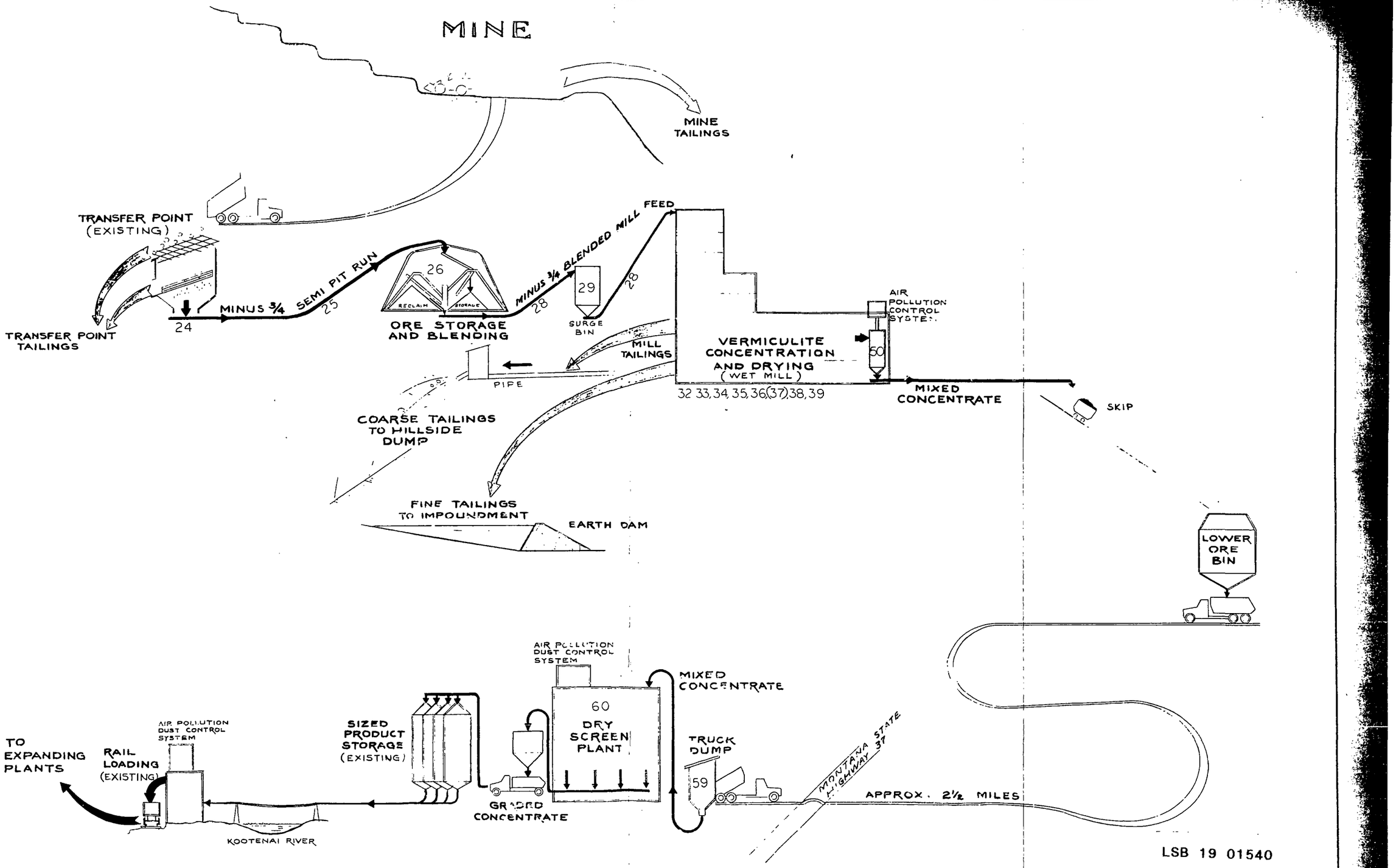
●	Pathway is believed to be complete, and which may provide an important contribution to the total risk to the receptor. This pathway will b evaluated using one or more lines of evidence.
O	Pathway is believed to be complete but is unlikely to be a major contributor to the total risk to the receptor (in comparison to one or more other pathways that are evaluated). This pathway will not be evaluated quantitatively.
	Pathway is incomplete or believed to be negligible; further evaluation is not warranted
?	Pathway that is or might be complete, but current data are not adequate to decide if it is a significant contributor to the total risk of the receptor.

LIBBY, MT VERMICULITE MINE

TYPICAL MASS BALANCE

(TONS/YEAR)





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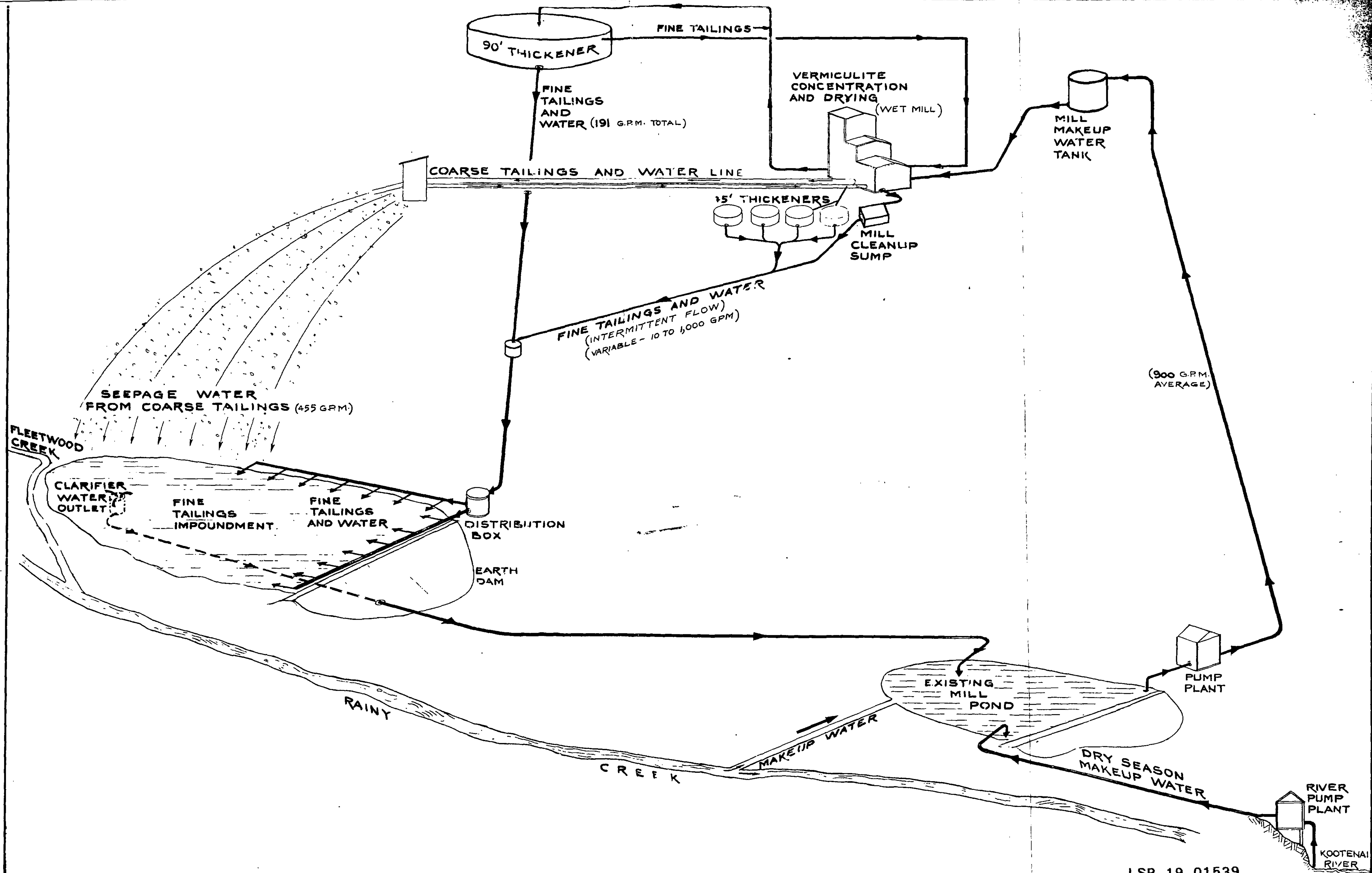
GRACE	W. R. GRACE & CO. CONSTRUCTION PRODUCTS DIVISION LIBBY, MONTANA	SCALE	
DESIGNED BY / DATE	TITLE	SHEET NO.	
DRAWN BY / DATE	SIMPLIFIED VERMICULITE CONCENTRATE FLOW DIAGRAM	PROJECT NO.	
CHECKED BY / DATE	BOVAY ENGINEERS, INC. SPOKANE - HOUSTON - BATON ROUGE	DRAWING NO.	
APPROVED BY / DATE			



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GRACE

W. R. GRACE & CO.
CONSTRUCTION PRODUCTS DIVISION
LIBBY, MONTANA

MILL WATER
RECYCLE SYSTEM

BOVAY ENGINEERS, INC.
SPOKANE – HOUSTON – BATON ROUGE